Cognitive Roots of Hearing Variability in Cochlear Implant Users

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BACKGROUND

Variability in speech perception has been observed in cochlear-implant (CI) users. Some hypothesize that the reasons behind such variability are varying spectral resolution of CI users after the implant, age of receiving CIs, and length of deafness. Another hypothesis is that it is due to differences in high-level cognition functions, such as contextual abilities, working memory, and general intelligence. If so, then CI users' speech perception attributes to their cognitive abilities.

EXPERIMENTS: Speech Perception, Working Memory, General Intelligence, and Spectral Resolution

Methods

- Speech Perception – with and without context
- Working Memory
- General Intelligence
- Spectral Resolution

Stimuli

- IEEE & nonsense sentences
- Reading span test
- Raven's Progressive Matrices
- Spectral ripple discrimination & detection

Subjects

Eligibility

- Native English speakers
- 18 or older

Groups

1. Normal Hearing (NH) subjects
   - Age range: 18-30
   - Average: 21
2. Cochlear Implant (CI) subjects
   - Age range: 58-72
   - Average: 65

Tasks

Task 1: Speech Perception

Sentence detection through a vocoder with and without noise in the background;

vocoder simulates CI with 12dB/oct spread for normal hearing NH subjects

Task 2: Working Memory

Logical sentence detection while memorizing a string of letters

Task 3: General Intelligence

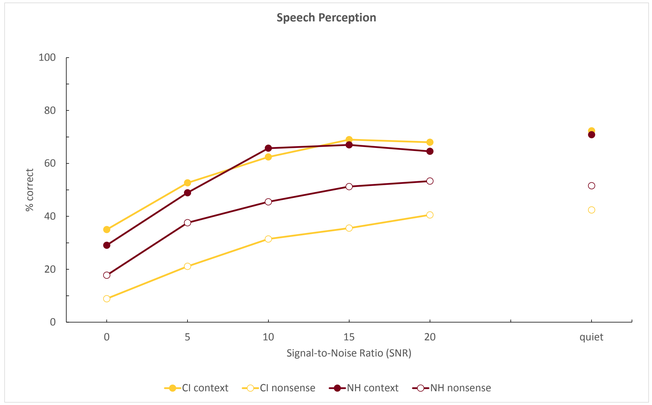
Filling in missing patterns by using spatial thinking

Task 4: Spectral Resolution

Detection of different sounds; vocoder simulates CI with 12dB/oct spread for normal hearing NH subjects

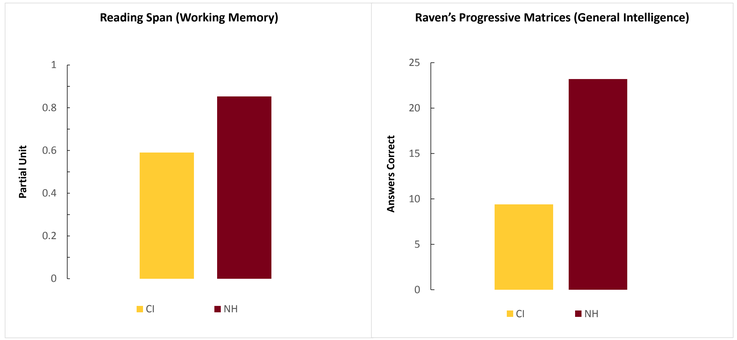
RESULTS

Speech Perception



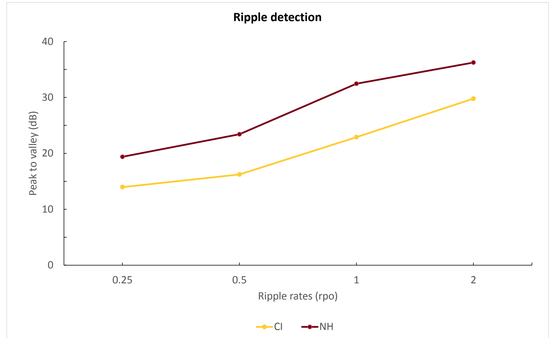
- Overall, both CI subjects and NH subjects performed better with context.
- CI subjects and NH subjects, who listened to vocoder with 12dB/oct spread, performed similarly with context.
- The gap between context and no context is greater for CI subjects than NH subjects.

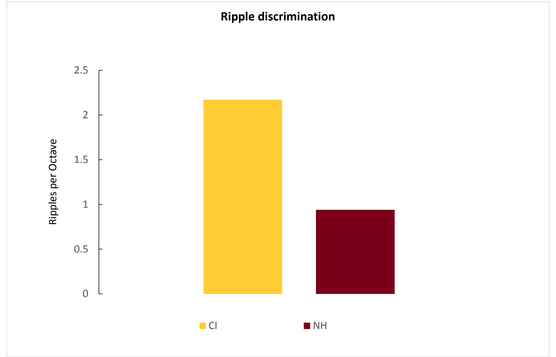
Cognition



- NH subjects performed better on both cognitive tests than CI subjects.
- On the reading span, on average, CI subjects had 60% correct while as NH subjects had 85% correct.
- For the reading span, the score represents the number of letters recalled in a correct position.
- On Raven's Progressive Matrices, on average, CI subjects had 10 correct while as NH subjects had 23 correct.
- The matrices set contained 36 problems.

Spectral Resolution





- For ripple detection, CI subjects detected sound with smaller differences in amplitude than NH subjects who listened to vocoder with 12 dB/oct spread.
- For ripple discrimination, CI subjects better differentiated than NH subjects, who listened to vocoder 12 dB/oct spread between stimuli where the frequency peaks of the ripples were closer together.
- CI subjects had better spectral resolution than NH subjects.

- Only 9 of 30 CI subjects and 13 of 30 NH subjects have been tested so far.

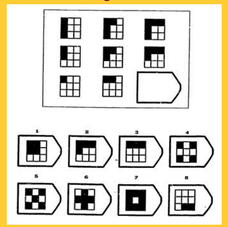
CONDITIONS

Contextual sentence
Ex. Glue the sheet to the dark blue background.

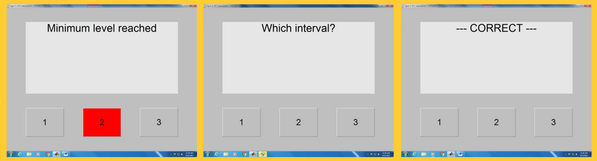
Non-contextual sentence
Ex. That ocean could shadow a peak.

Reading Span Test

Raven's Progressive Matrices



Ripple detection/ Ripple discrimination



DISCUSSION

- The results suggest that CI subjects use more contextual cues than NH subjects when perceiving speech.
- Due to the significant differences in cognition between CI subjects and NH subjects, age-matched NH subjects are to be recruited as the next step.